COASTAL SANDROCK FORMATION AT EVANS HEAD, N.S.W.

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(Plate v; one Text-figure.)

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Synopsis.

Two extensive deposits of coastal sandrock are described. Chemical and physical properties of this material are compared with similar properties of nearby sandy podzol soils and the conclusion reached that the sandrock was an A horizon of a peat bog soil which formed during the last great glacial recession.

Benching of the deposit at the sea front forms a valuable record of the degree and progression of the Recent emergence, mainly as a result of the unique physical properties of the sandrock.

The widespread occurrence of "sandrock" in the coastal regions of southern Queensland and northern New South Wales has been known for many years, but Coaldrake (1955) recently redirected attention to these deposits as possible sources of evidence in the determination of Pleistocene and Recent eustatic sea movements.

Two extensive deposits of coastal sandrock found on the north coast of New South Wales are here described, and some indication given of their probable genesis and significance in the interpretation of the Quaternary history of the area.

Nature and Distribution of the Deposits.

The sandrock deposits occur as two discrete areas to the north and south of Evans Head on the Evans River (Text-fig. 1) where they underlie, in part, sandy coastal plains of Pleistocene and Recent origin similar to those described by David (1950). They have been briefly described by Stonier (1895).

Both deposits outcrop at sea-level on the ocean front forming low cliffs or a series of platforms, the highest of which are 15 feet above high water mark (H.W.M.). While the exposures are nowhere more than one chain in width, they extend for two miles as nearly horizontal beds.

Loose dune sand 5–30 feet deep overlies the upper surface of the outcrops forming unstable cliffs at the sea edge. These sands frequently contain thin, unconsolidated horizons of organic deposition.

The Gap Deposit.

The southern deposit near "The Gap" outcrops at the edge of a coastal plain which is bounded to the west and north by resistant hills of Jurassic sandstone and shale (Text-fig. 1). The sandrock rises 15 feet above H.W.M. as a massive, consolidated, but rather soft deposit with indistinct horizontal banding (Plate v, fig. 1). Three well-defined horizontal platforms can be recognized, the highest forming the upper surface of the sandrock with two lower levels at 8 feet and 12 feet 6 inches above H.W.M. Where erosion has not cut into and removed one or both of the lower levels, they retain a constancy in height and frequency of occurrence which enables them to be traced over the full length of the exposure (Plate v, fig. 2).

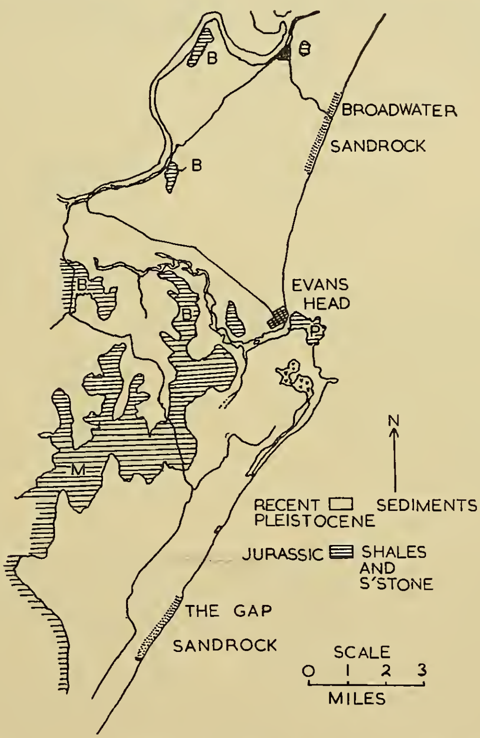
The deposit is overlain by dune sand of variable thickness.

The sequence listed below and shown in Plate v, figure 3 is typical of the Gap deposit passing through the unconsolidated deposits to sandrock at sea-level.

Bed	Thickness in feet. Minimum.	Maximum.
(1) Pale grey dune sand (A horizon)	½	1½
(2) White dune sand	4	30
(3) Shell bed (kitchen midden)	0	1
(4) White dune sand	2	4
(5) Grey humus dune sand (A horizon ?)	1	2
(6) White sand	0	1½
(7) Coastal sandrock	15*	15

* Extends a further 6 feet at least, below sea-level.

The grey humus dune sand (5) may directly overlie the sandrock. The shell bed (3) has only been found at one site.



Text-fig. 1.—Locality map showing sandrock deposits.

The Broadwater Deposit.

The northern deposit is associated with the large tract of stabilized sand running north of the Evans Head airstrip towards Broadwater. Although this deposit appears to be contemporaneous with that to the south, it is much dissected by wave action and the bench features observed in the Gap deposit are not seen. This is partly due to the presence of slightly compacted white sand, interposed between sandrock at 6 feet (this level is somewhat variable) and at 15 feet above H.W.M. (Plate v, fig. 4). The sand which attains a thickness of 8 feet shows darker bands of unconsolidated organic staining of varying width. It is apparent that a major time break in depositional conditions occurred and that large scale accumulation of organic matter when finally resumed, did not persist for any great length of time.

Variable depths of unconsolidated dune material similar to that overlying the southern sandrock deposit are found above the 15–16 foot level of the compacted organic layer.

Because the foregoing features indicate less uniformity in formation than the Gap deposit, further studies were not made on this deposit.

Composition of Sandrock and Related Deposits.

The coastal sandrock has been described by various workers under such names as painted sand, beach rock or black rock, the colour being attributed to either organic matter, or iron, or both.

At the Gap it is a medium-grained, soft and friable sandstone, the individual grains of which are cemented by organic matter. The mineralogical content is primarily quartz, but various resistant "heavy" minerals such as rutile, zircon, tourmaline, monazite, etc., are found in small amounts.

The colour is variable from dark brown (7·5 YR 3/1)* in the upper part of the bed to a very dark brown (10 YR 2/2) near sea-level. Bryan and Jones (1945) considered that colour was controlled by the intermixed organic matter. Both quantity and type would appear important.

Table 1.

Analytical Data for Sandrock and Associated Deposits.

Level. (Feet above H.W.M.)	Nature of Material.	Percentage Loss on Ignition.	Percentage Fe (HCl Extractable).
31	Grey humus dune sand (A horizon) ..	1·8	n.d.
30	Unconsolidated white dune sand ..	0·2	0·006
17½	Unconsolidated grey humus sand (A horizon ?)	2·3	n.d.
15	Brown peaty sandrock	68·0	0·009
12	Black sandrock*	19·0	0·015
12	Brown peaty sandrock	28·0	trace
0	Black sandrock	5·7	0·015
0	Black sandrock	5·0	n.d.

* Peaty material excluded from sample.

Under the microscope the individual grains of the darker sandrock are found to be coated with a continuous adherent "skin" of organic matter while the grains of the browner variety show a looser, patchy and somewhat flaky distribution of organic matter mainly concentrated at the points of contact.

Numerous small, highly humified roots up to half an inch in diameter are a common feature of the upper portion of the sandrock bed. Although some of the roots may have penetrated the sandrock after formation, the evidence of a vertically embedded tree trunk 7 feet below the upper surface proves the presence of large woody plants at the time of development.

These plant remains increase the variability of the organic matter content of the sandrock at the top of the deposit, so that the textural properties range from peat to peaty sand over distances of a few inches. The matrix of consolidated, sandy material contributes structural stability to the crumbly, humified material.

Below 8 feet from the upper surface, the sandrock becomes more homogeneous and the structure of plant material is no longer recognizable. A decrease in the organic matter content of bulk samples of sandrock collected from various positions down the deposit is shown in Table 1.

Many authors, e.g. Stonier (*op. cit.*), Ball (1924), have described iron staining of sandrock deposits, but in the samples from this locality the total iron is extremely low

* Munsell Colour of air dry sample.

(Table 1). On ignition the sandrock burns to a loose white sand. Maze (1941) found somewhat similar results for thick organic hardpan deposits near Newcastle.

The exact nature of the sandrock in this locality is thus very much a function of the amount and kind of organic matter.

The analytical data for the unconsolidated material above the sandrock at the Gap are also tabulated. It is low in both iron and organic matter, but the values for the latter rise in the organic layers which are thought to represent soil A horizons. In the buried horizon immediately over the sandrock, small amounts of a white mineral adhere, as clay and silt sized particles, to individual unweathered quartz grains. These quartz grains are rounded and of smaller average diameter (·2 mm.) than in the sandrock (·4 mm.).

The dune sand has not been closely examined, but appears similar to that found elsewhere on the North Coast.

Genesis of the Gap Sandrock.

Coaldrake (*op. cit.*) lists three different types of coastal sandrock, viz. truncated "fossil" B horizons of former podsols, compressed peats and peaty sands, and compressed silty swamp deposits. The first problem, therefore, is whether the Gap deposits are A horizons or B horizons of former soils or perhaps a combination of both.

Table 2.

Analytical Data for Ground-water Podzols.

Profile Number.	Depth. (Inches.)	Colour.	Munsell Notation.	Percentage Loss on Ignition.	Percentage Fe (HCl Extract).
		Ground-water Podzol A1 Horizon.			
1149.1	0–6	Grey.	10YR 5·5/1	2·1	0·022
1148.1	0–6	Grey.	10YR 6/1	1·9	0·081
1147.1	0·6	Very dark greyish brown.	10YR 3·5/2	8·0	0·086
1146.A1	0–6	Grey.	10YR 4/1	7·8	0·027
1145.1	0–6	Dark grey.	10YR 4/1	11·6	0·059
		Ground-water Podzol B Horizon.			
1149.5	38–48	Very dark brown.	10YR 2/2	2·1	0·301
1148.4	24–48	Very dark brown.	10YR 2/2	1·7	0·521
1147.4	15–36	Very dark grey.	10YR 3/1	1·6	0·327
1145.3	11–26	Dark brown.	7·5YR 3/1	4·3	0·009
		Sandrock.			
Range	—	Dark brown. Very dark brown.	7·5YR 3/1 –10YR 2/2	68·0 –5·0	0·009 –0·015

The content and stage of decomposition of organic matter and the content and distribution of iron are the soil properties most likely to yield information on this subject. Accordingly, some comparisons of these particular properties of the sandrock with those of the organic surface and B horizons of ground water podzols forming at present in the area, have been made.

In Table 2 the iron contents of the B horizons of the podzols are shown to be generally higher than in the sandrock samples. However, the low value in the typical B horizon hardpan in sample 1145·5 from a heath swamp indicates that iron need not invariably be present in high amounts. Although Maze (*op. cit.*) found a sandy iron hardpan to be characteristic of freshwater swamps it appears that near Evans Head the iron content is not a good diagnostic property of soils formed under these conditions. The organic matter content (equivalent to loss on ingnition of the oven dry (105° C.) sample) appears to be a more useful indicator. Even though the organic matter is frequently quite high in the A horizons of these soils it is still far lower than the highest levels found in the sandrock. In the B horizons the amounts present are all lower, although in sample 1145, which is waterlogged for most of the year, the amount present does approach the lower values found in the sandrock.

These analytical results, though few in number, indicate that the upper sandrock at the Gap is unlikely to be either an A or B horizon of a groundwater podzol while closer to sea-level, on organic matter content alone, the possibility of either an A or B podzol horizon cannot be overruled.

The retention of cell structure of some of the original vegetation above the 8-foot level in the sandrock also indicates an A horizon of organic matter accumulation rather than colloidal movement and subsequent precipitation as expected in a B horizon. The gradual change in character and content of the organic matter with increasing depth, however, appears to be the result of greater decomposition and reprecipitation as indicated by the dispersed organic matter coating the grains of the sandrock at lower levels. This may have been due to either movement from the overlying horizon, in which case it would be classified as a B horizon, or possibly more favourable conditions of decomposition and precipitation *in situ* in the A horizon before or after burial.

The thin horizontal banding effects which extend through the full exposure are also suggestive of successive A horizon accumulation which could have scarcely survived the obliterating effects of organic matter decomposition, movement, and redeposition, associated with podzolization. The evidence therefore favours A horizon accumulations of Peat Bog soils ranging from a sandy peat in the upper part of the exposure to a peaty sand with increasing depth.

It follows that certain conclusions may be reached about the environment during the period of organic matter accumulation, and prior to the consolidation of the soil to sandrock.

There can be little doubt that a rising water-table was associated with this formation and that the rise must have continued for a long time—possibly thousands of years—for such a thick deposit to form. The lack of any well-defined breaks in the overall depositional pattern would indicate continued uniformity of conditions during this period.

Such conditions could result from two different physiographic situations, with peat formation in either (1) depressions or lakes at any height above sea-level where internal restriction of drainage by impervious layers favoured continued rise in the water-table, or (2) low-lying areas at sea-level where either positive eustatic sea movement or negative land movement gradually raised the water-table.

The field evidence points strongly to the second hypothesis. The uniformity of the depositional pattern of sand and organic matter in a horizontal distance of two miles implies a uniform rate of formation over the length of the deposit. It is less likely that such uniformity would prevail in depression situations above sea-level where wider water-table fluctuations might be expected. More significantly the constancy in level of the upper surface of the deposit reflects some sudden fall in the water-table level which arrested development and which could only be the result of large scale physiographic changes.

It is tempting, therefore, to suggest that the sandrock was built up during an eustatic sea rise and that the height of 15 feet above H.W.M. attained by this deposit correlates with the maximum sea height during the final stage of the last glacial recession.

Some additional information on the genesis of the deposit may be gleaned from the humified wood remains scattered through the sandrock above the 8-foot level. These have been identified mainly as *Agathis*, the evidence for this being included in a following paper (Bamber and McGarity, 1956).

The three living representatives of this genus in Australia are found in habitats where the water-table may be close to, but not immediately at the soil surface (L. S. Smith, priv. com.). It is thus suggested that *Agathis* forest communities may have fluctuated in development as the water-table fluctuated and that conditions suitable for the deposition of sand, and perhaps death of the trees, alternated with periods of forest re-establishment. Such a cycle of development could be the consequence of closely spaced but irregular rises in the water-table with intervening falls, and could explain the faint horizontal banding of the deposits.

If such were the case, then this deposit may have been formed in the interdune areas behind the littoral in situations similar to those in which *Agathis* forests are now found in south-eastern Queensland.

The Broadwater deposit, as indicated above, shows a break in the depositional pattern above the 6-foot level. The final layer of sandrock at approximately 15 feet, however, may be regarded as tentative evidence of the contemporary development of this deposit.

Erosion Benches.

Raised platforms are found at 15 feet, 12 feet 6 inches and 8 feet in the Gap deposit. While the upper platform is merely an effect of erosion on materials of differing hardness, the lower benches are the consequence of wave cutting.

It appears that the sandrock was sufficiently soft to record the Recent drop in sea-level and yet sufficiently hard to enable preservation of the platforms so formed, to the present day. Other dissected platforms may also be proved on more detailed investigation (e.g., at 4 feet above H.W.M.), but the evidence here is for sufficient check in the falling of the sea-level to produce only two major platforms.

This evidence would support the findings of other workers (*see* David, 1950) in Australia for Recent benching. It is inadvisable to attempt correlation of these levels with those found elsewhere until more precise methods of datum determination are available, but some relationship with the findings of Beasley (1947) for eustatic sea-levels in southern Queensland appears to exist.

Unconsolidated Sand Deposits.

The deposits of dune sand immediately overlying the sandrock in both areas were apparently formed during the mid-Recent arid period and stabilized with the onset of wetter conditions. The dune sand is now being eroded, revealing organic matter horizons which suggests that temporary ameliorations of climate may have intervened during the period of accumulation.

The organic horizon (5) in the Gap deposit below the shell bed was an earlier deposit apparently close to the commencement of the arid period. The shell bed (an aboriginal kitchen midden) indicates the proximity to the sea, as well as the Recent age of the dune material. The sea front was evidently not very far to the east of its present position.

Conclusion.

Though the evidence and discussion in this paper is of a preliminary nature, it is hoped that attention will be drawn to the importance of palaeopedology as an aid in the elucidation of the Pleistocene and Recent chronology of the coastal sediments.

The study has indicated that the sandrock at the Gap is a former peat bog. A horizon formed under conditions of arrested decomposition associated with a rising water-table. This rising water-table is thought to be the consequence of a rising sea-level during the last glacial recession. If this is confirmed the overlying dune sands are of mid-Recent age and the past development of this part of the coast would appear very similar to the present.

Mainly through the unique physical properties of the sandrock, benching of the deposit at the sea front has occurred and this forms a valuable record of the degree and progression of the Recent emergence.

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EXPLANATION OF PLATE V.

1.—The Gap. Sandrock (15 ft.) exposed at the sea edge. Note the horizontal banding.

2.—The Gap. Benching, showing levels at 12 ft. 6 in. (1) and 8 ft. (2) above H.W.M.

3.—The Gap. Sequence of unconsolidated and consolidated beds. The numerals (1-7) refer to beds as listed in text.

4.—Broadwater. Sandrock beds separated by unconsolidated sand.